(12) UK Patent Application (19) GB (11) 2 371 934 (13) A

(43) Date of A Publication 07.08.2002

(21) Application No 0102119.5

(22) Date of Filing 26.01.2001

(51) INT CL^7
H04N 7/08 // H04N 1/32

(52) UK CL (Edition T)
H4F FBB F22

(56) Documents Cited
EP 1001604 A2 WO 2000/065536 A1

(58) Field of Search
UK CL (Edition S) H4F FBB
Online: WPI, EPODOC, JAPIO, INSPEC

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(54) Abstract Title
Embedding data in material using an embedding scale

(57) An apparatus for embedding data in material information comprises an embedding processor operable to select at least one symbol of the material information for embedding a symbol of the data, to compare a value of the material symbol with an embedding scale divided into predetermined regions, each of the regions being associated with a value of the data symbol, and consequent upon the comparison to adjust the value of the material information symbol to fall within the nearest of the predetermined regions of the embedding scale associated with the value of the data symbol to be embedded, wherein at least one adjacent region of the embedding scale is associated with the same value of the data symbol to be embedded. Hence, there is an increased likelihood of correctly recovering embedded data, or conversely reducing an amount by which the material symbols must be changed whilst providing an improved immunity to noise.

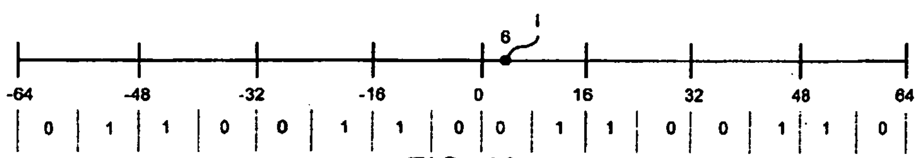

FIG. 4A

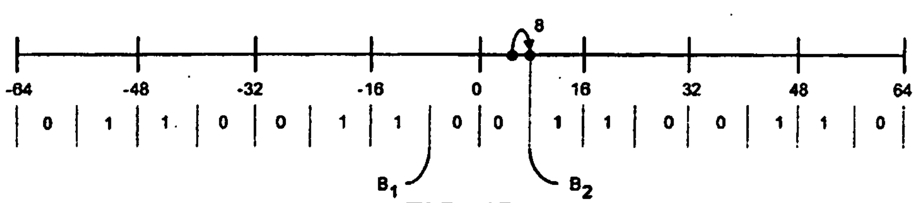

FIG. 4B

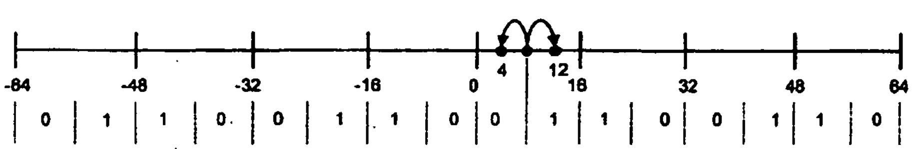

FIG. 4C

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

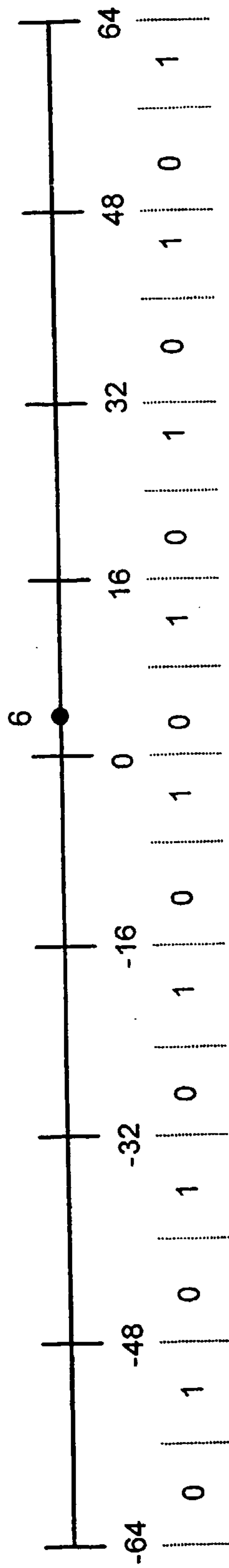


FIG. 1A

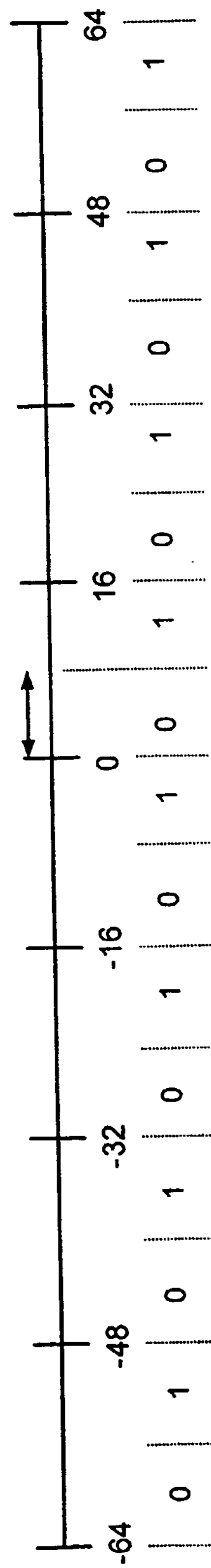


FIG. 1B

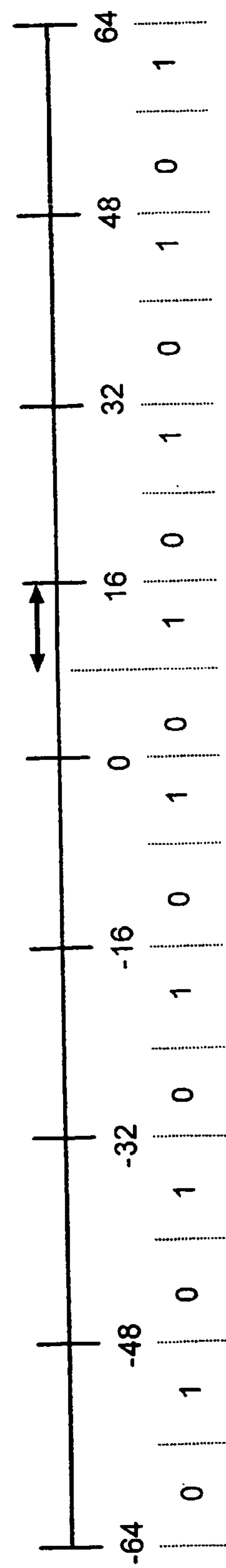


FIG. 1C

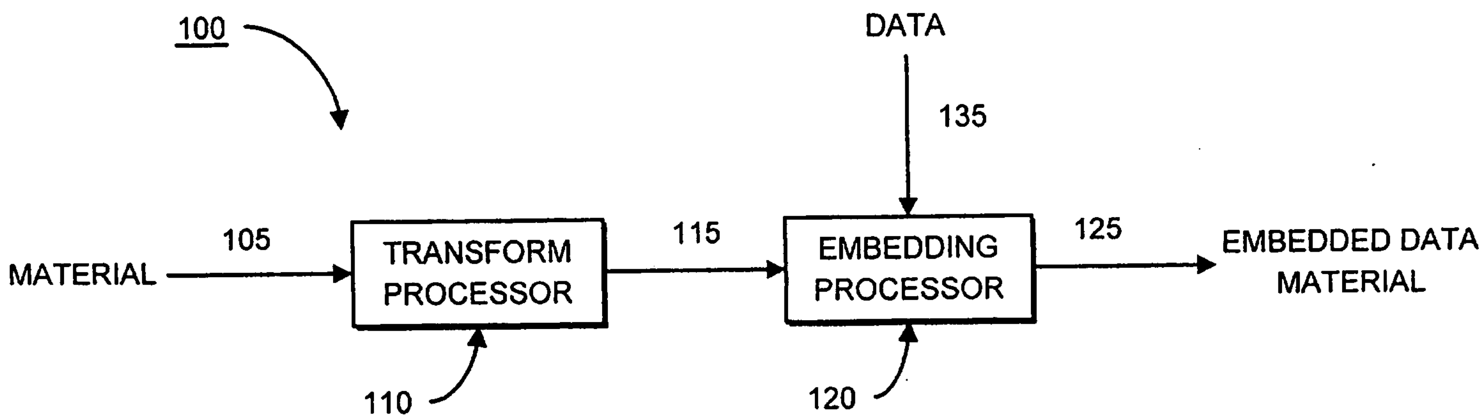

100
MATERIAL
105
TRANSFORM PROCESSOR
110
115
DATA
135
EMBEDDING PROCESSOR
120
125
EMBEDDED DATA MATERIAL

FIG. 2

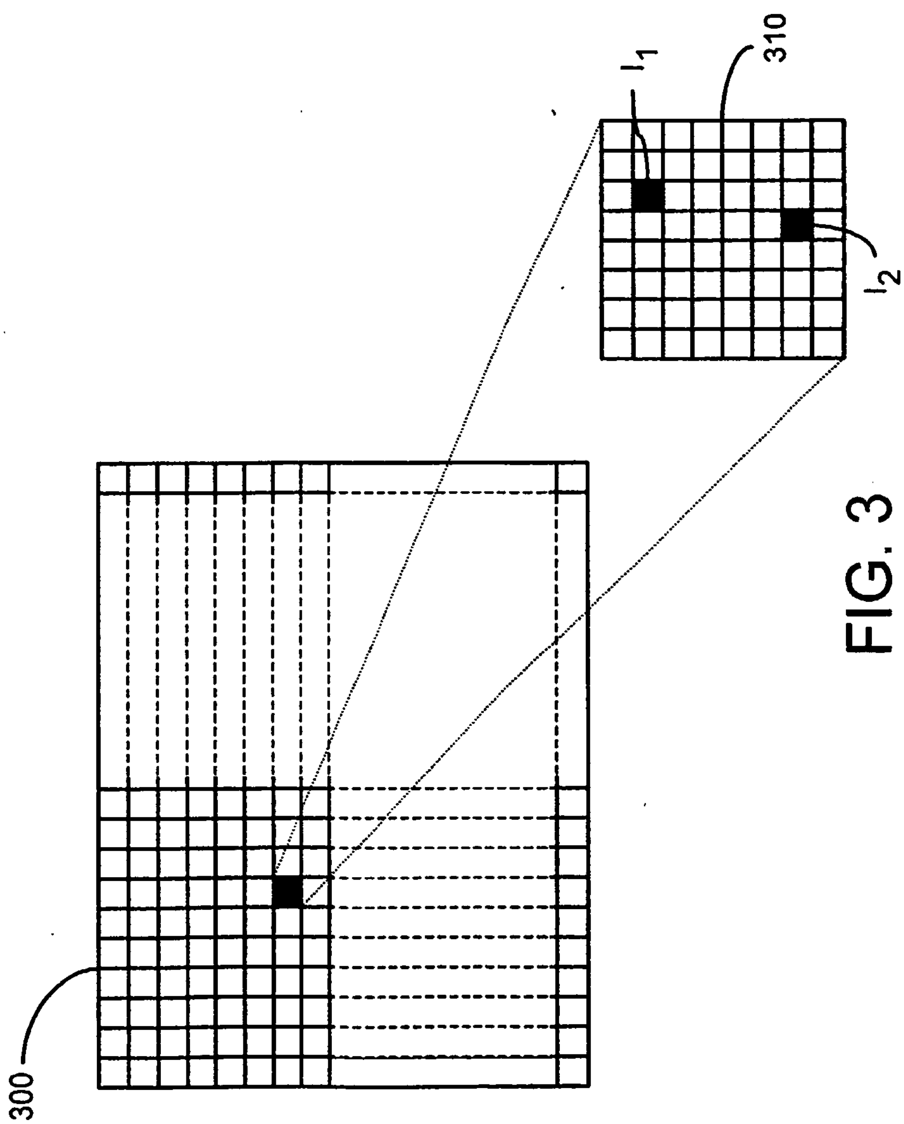


FIG. 3

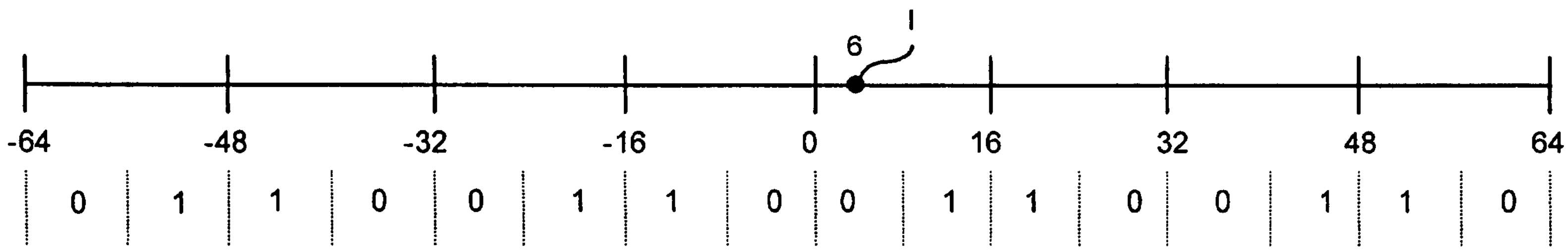


FIG. 4A

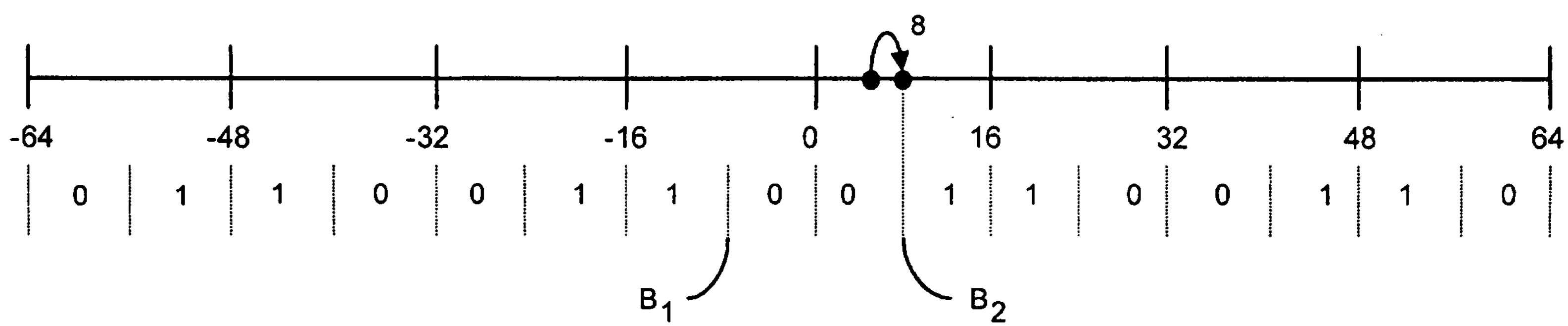


FIG. 4B

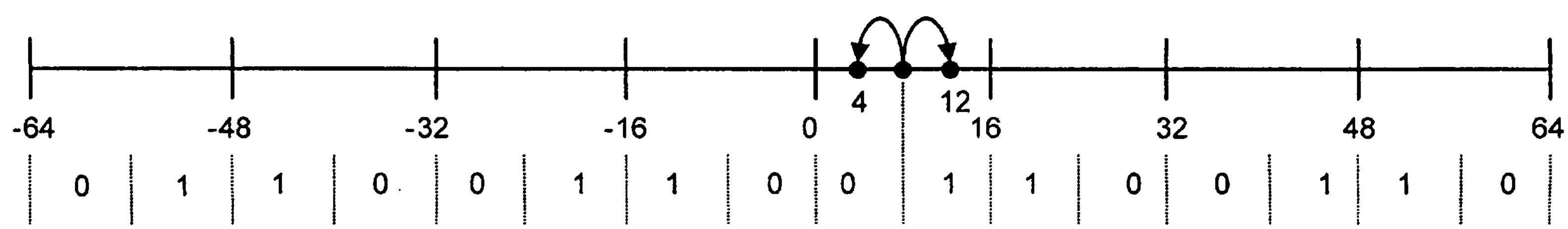


FIG. 4C

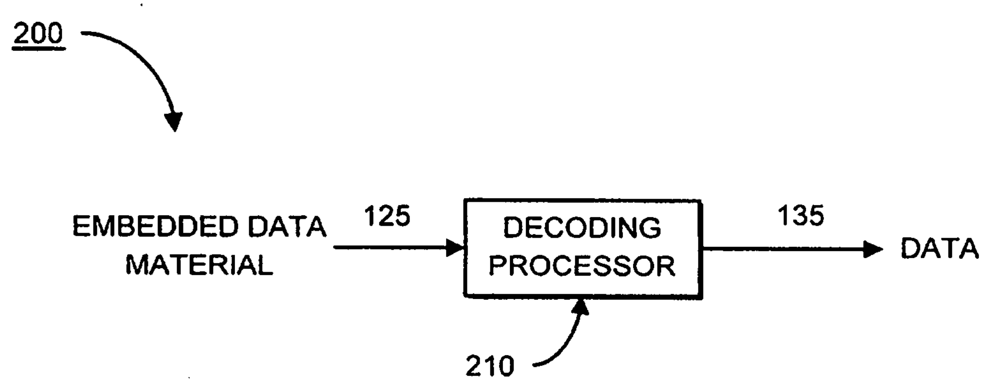

200
EMBEDDED DATA MATERIAL
125
DECODING PROCESSOR
135
DATA
210

FIG. 5

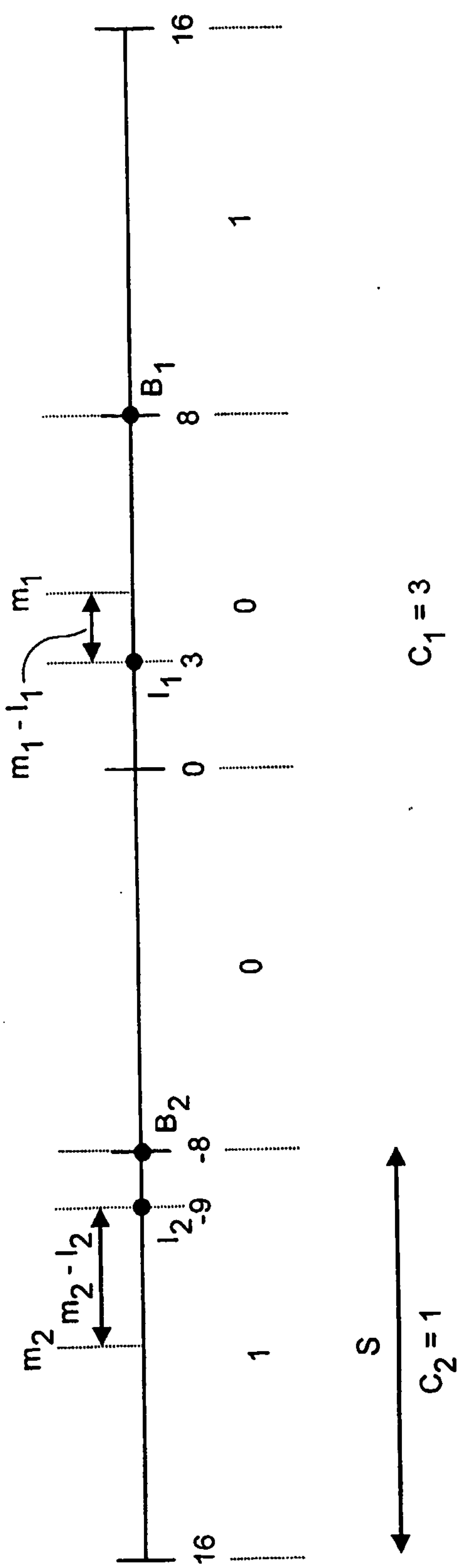


FIG. 6

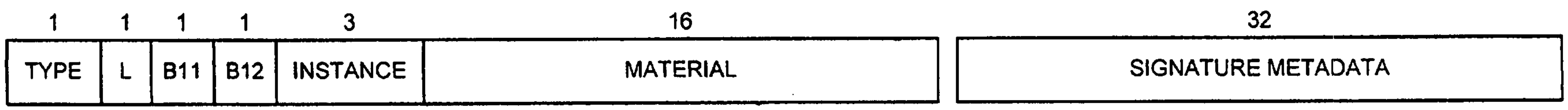
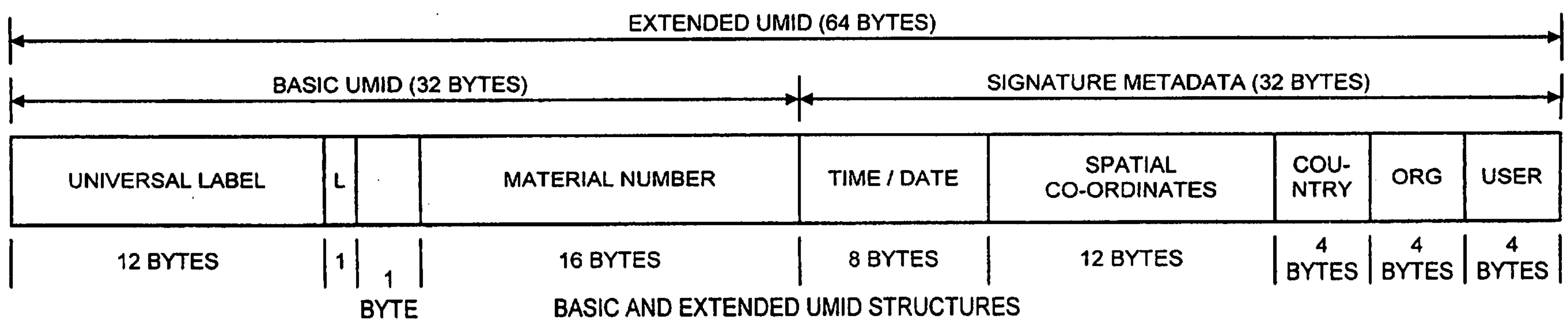


FIG. 7A



BASIC AND EXTENDED UMID STRUCTURES

FIG. 7B

EMBEDDING DATA IN MATERIAL

FIELD OF THE INVENTION

The present invention relates to embedding data in material.

In this application, material means one or more of video material, audio material and data material. Video material in this context may be still images or moving images.

BACKGROUND OF THE INVENTION

It is known to embed data symbols in material information.

A previously proposed arrangement for embedding data symbols in material information utilises a transform domain representation of the material information. Transform domain symbols are selected and then modulated with the embedded data symbols, before the transform domain symbols are reverse transformed to reproduce the material information in which the data has been embedded. An example of such a previously proposed arrangement is illustrated in Figures 1A, 1B and 1C.

The modulation of the selected transform domain symbols is performed using an embedding scale which is shown in Figure 1A. As shown in Figure 1A the embedding scale is divided into predetermined regions. Each region is assigned a possible value of the data symbol to be embedded. For the example of binary data each region is assigned a binary value of '1' or '0'.

The value of a selected transform domain symbol, which in the illustrative example is "6", is then adjusted in accordance with the value of the data symbol to be embedded. The adjustment is made to the effect that the value of the transform domain symbol falls within the nearest region of the encoding scale which is representative of the data symbol to be embedded. Hence, the value of the transform domain symbol may be adjusted to fall mid-way within the "0" to "8" region of the encoding scale when it is required to embed a binary '0' as illustrated in Figure 1B. Alternatively the value of the transform domain symbol is adjusted to fall mid-way within the "8" to "16" region of the encoding scale when it is required to embed a binary '1' as illustrated in Figure 1C.

Thus, when the embedded data is detected and recovered, the transform domain symbol in which the data symbol has been embedded is known, and the encoding scale

is known. so that the region in which the adjusted transform domain symbol falls indicates the value of the embedded data symbol.

As will be appreciated, in order to minimise the effect of embedding the data on the material information, the transform domain symbol should be preferably changed by as small an amount as possible. This encourages the use of a larger number of predetermined regions in the encoding scale, the range of values of the transform domain symbol being made smaller. As a result, the amount of adjustment required to be made to the transform domain symbol so that it falls within a region assigned to a particular data symbol value is smaller.

However, a result of reducing the range of values of the encoding scale is to reduce the likelihood of correctly recovering the value of the embedded data symbol. This is because processing such as compression encoding and analogue to digital and digital to analogue conversion has an effect of changing the values of the original transform domain symbol. This, in combination with other inaccuracies in the data detection and recovery process, can be regarded as noise. Therefore, the smaller the range of the encoding scale regions the more likely noise will cause the value of the transform domain symbol to be changed to an adjacent region, thereby potentially erroneously representing a false value for the embedded data symbol. Hence, it will be appreciated that noise having a value larger than half the magnitude of the encoding region will result in the value of the transform domain symbol being changed to another region, thereby potentially erroneously representing a false value for the embedded data symbol. In this example, experiencing noise which causes the value of the transform domain symbol to change by greater than "4" may result in a false value for the embedded data symbol.

It is desired to provide an encoding and decoding technique, which has improved robustness to noise.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention there is provided an apparatus for embedding data in material information, the apparatus comprising an embedding processor operable to select at least one symbol of the material information for embedding a symbol of the data, to compare a value of the material information symbol with an embedding scale divided into predetermined regions, each of the

regions being associated with a value of the data symbol, and consequent upon the comparison to adjust the value of the material information symbol to fall within the nearest of the predetermined regions of the embedding scale associated with the value of the data symbol to be embedded, wherein at least one adjacent region of the embedding scale is associated with the same value of the data symbol to be embedded.

Hence, embodiments of the present invention seek to provide an advantage in increasing the likelihood of correctly recovering embedded data, or conversely reducing an amount by which the material symbols must be changed whilst providing an improved immunity to noise. This is effected by assigning the same embedded data symbol value to adjacent regions of the encoding scale. For the binary example, instead of alternating between binary '1's and '0's, the encoding scale pairs regions encoding '1's and '0's together. As a result the same encoding scale ranges, requiring the same adjustment to the material symbols, can be maintained whilst providing an improved immunity to noise. This is because even if the effect of noise on the adjusted material data symbol is to change its value to the next region, the value of the corresponding embedded data symbol is more likely to remain the same. Hence, the effect of noise would have to change the adjusted material data symbol by a greater amount for an error to occur.

Thus it has been found that the embedding technique provides an improved robustness to noise. As will be appreciated, the likelihood of the value of a material symbol being changed by noise to an adjacent region having a different associated value is generally the same as being changed to an adjacent region having the same value. Therefore, statistically, there is an increase in the likelihood over the above-described technique of correctly recovering embedded data for the same amount of noise adjustment to the material symbol. Alternatively, the likelihood of correctly recovering embedded data can be maintained whilst applying a reduced amount of adjustment to the material symbol in comparison to the existing technique.

Although the data symbols may be embedded in the material information by adjusting the selected symbols of the material information in preferred embodiments the apparatus may comprise a transform processor operable to transform the material information into the transform domain, the embedding processor being operable to embed the data symbols to be embedded by comparing and adjusting selected

transform domain material information symbols in accordance with the embedding scale.

The transform processor may be a wavelet transform processor or a Discrete Cosine Transform (DCT) processor.

According to a second aspect of the present invention there is provided an apparatus for detecting and recovering data embedded in material information by the apparatus according to the first aspect of the present invention.

Other aspects and features of the present invention are defined in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention, reference will now be made by way of example to the accompanying drawings in which:

Figures 1A to 1C are schematic diagrams illustrating a previously proposed technique of embedding data in material;

Figure 2 is a block diagram illustrating an apparatus for embedding data in material information according to an embodiment of the present invention;

Figure 3 is schematic diagram illustrating material information;

Figures 4A to 4C are schematic diagrams illustrating a technique used by the apparatus of Figure 2;

Figure 5 is a block diagram illustrating an apparatus for decoding embedded data in material information produced by the apparatus of Figure 2;

Figure 6 is a schematic diagrams illustrating a technique used by the apparatus of Figure 5; and

Figures 7A and 7B illustrate the structure of a Universal Material Identifier (UMID).

DESCRIPTION OF PREFERRED EMBODIMENTS

EMBEDDER/ENCODER

Figure 2 is a block diagram illustrating an apparatus 100 for embedding data in images 105 according to an embodiment of the present invention. In this preferred embodiment the images 105 are processed in the transform domain as it has been found that, particularly with Discrete Cosine Transforms (DCT), the embedding is more robust, less perceptible, and changes to DCT values are spread over a number of pixels in spatial domain. However, it will be appreciated that the present invention is not limited to this and could equally be applied to spatial domain representations of material information 105.

The apparatus 100 may receive material information generally, being either audio material, video material or data material. The material information comprises of a plurality of bits, bytes or symbols. It will be appreciated that the characteristics of the material information which is to encode the data symbol 135 will determine the embedding scale to be used.

Embodiments of the present invention find application in embedding data in any form of material information. However, in the example embodiments the material information is image data.

The apparatus 100 receives an image 105 and generates a transform domain representation of the image 115 using a transform processor 110. Where the material information 105 comprises a plurality of frames the transform processor may be arranged to produce a transform domain representation of the material information 115 for each frame of material information 105. An embedding processor 120 receives the transform domain representation of the material information 115 and data 135 to be embedded. The data comprises a plurality of data symbols. The embedding processor 120 adjusts one or more, but generally, at least one selected transform domain symbol of the transform domain representation of the material information 115 to fall within the nearest predetermined region of an embedding scale corresponding to the value of the data symbol to be embedded. As will be explained shortly, the adjusted transform domain symbols represent the value of data symbols being embedded.

For the example of video images comprising a number of frames, the embedding processor 120 may be arranged to adjust transform domain symbols of the

transform domain representation of the material information 115 in different frames. Hence, some frames may have no adjusted transform domain symbols whilst other frames may have more than one transform domain symbols. To improve the likelihood of correctly recovering the embedded data in the presence of noise, in one embodiment, the same data symbol may be embedded more than once. The data symbol may be any particular data value to be embedded. In another embodiment the data 135 may comprise a Universal Material Identifier (UMID) or a subset thereof. The use of a UMID is advantageous as it provides for unique identification of the material information 105. UMIDs are described in more detail below in the section entitled UMIDs. The data 135 may also be encoded using known error correction coding techniques such as Reed-Solomon encoding or convolutional encoding prior to being embedded. This is advantageous since error correction coding further improves robustness to noise.

One such example of material information 105 is a DCT transform 300 illustrated in Figure 3. Here, one macro block 310 of 8x8 pixels is selected and two predetermined transform domain symbols I_1, I_2 are adjusted to encode respective data symbols.

EMBEDDING/ADJUSTING TECHNIQUE

The operation of the embedding processor 120 will now be explained in more detail with reference to embedding data in the DCT transformed image in Figure 3.

Figures 4A to 4C are schematic diagrams illustrating a technique used by the apparatus 100.

Figure 4A shows an embedding scale which is divided into predetermined regions. Each region has boundaries, the boundaries being the lower and upper values of the region. Each region is assigned a possible value of the data symbol to be embedded. It will be appreciated that any suitable value could be assigned. For the example of binary data each region is assigned a binary value of '1' or '0'. Two adjacent regions of the encoding scale form a pair and each pair is assigned the same embedded data symbol value. For the binary example, the paired regions are assigned alternately '1's and '0's.

The transform domain symbol I in this illustrative example has a value of "6" but may have any integer value between "–64" and "+64". It will be appreciated that

the transform domain symbol I may have any value within a range of any suitable size and that the range need not have both positive and negative values.

The value of the transform domain symbol I in this illustrative example is then adjusted in accordance with the value of the data symbol to be embedded, to the effect that the value of the transform domain symbol I is adjusted to fall within the nearest region of the encoding scale which is associated with the data symbol to be embedded. Consider that a binary '0' is to be embedded in the transform domain symbol I, the adjustment of the transform domain symbol I is illustrated in Figures 4B and 4C.

In Figure 4B, the location of the nearest boundary between paired regions is determined. In this example, the nearest two boundaries B_1, B_2 exist at the values "8" and "-8". It will be appreciated that various techniques could be used to determine the nearest of the boundaries such as by the use of look-up tables, through arithmetic derivation or the use of counters. In preferred embodiments, the values of the boundaries are subtracted from the value of the transform domain symbol I and the boundary with the smallest result is selected. In this illustrative example, the nearest boundary is determined to be at the value "8".

In Figure 4C, the value of the selected transform domain symbol I is then adjusted in accordance with the value of the data symbol to be embedded. In this example, a value of "4" is subtracted from the boundary value to encode a binary '0' such that the value of the transform domain symbol I is adjusted to be "4". Had a binary '1' to be encoded then a value of "4" is added to the boundary value such that the value of the transform domain symbol I is adjusted to be "12". The value of "4" corresponds to half the range of the predetermined region and results in the value of the transform domain symbol I being adjusted to the mid-point of the nearest of the embedding scale regions which encodes the data symbol to be embedded.

Accordingly, the same amount of adjustment is made to the transform domain data symbol I as in the prior art approach. It will be appreciated that other techniques for adjusting the value of the selected transform domain symbol I could be used.

As explained above, noise can cause the transform domain symbol I to fall within a different region. As such, noise can cause the value of the transform domain symbol I to change by a value greater than 4 with the effect that a false value for the embedded data symbol may be decoded as is the case in the prior art. This effect is

particularly likely in the case of JPEG compression encoding. However, depending on the probability distribution of the noise, small changes of the transform domain symbol are more likely, so that, for example, in the case of Gaussian noise it can be seen that in approximately 50% of cases the value of the transform domain symbol I will be likely to change to a value greater than "4", but still represent the correct embedded data symbol, by falling within the adjacent region of the embedding scale encoding the same data value.

It will be appreciated that this improved likelihood of correctly recovering the value of the embedded data symbol provides significant performance advantages particularly when recovering data from material information which has been subject to processing such as compression encoding and analogue to digital and digital to analogue conversion.

Whilst in preferred embodiments the value of the transform domain symbol I is adjusted to a value being the mid-point of the nearest of the embedding scale regions which encodes the data symbol to be embedded it will be appreciated that the value of the transform domain symbol I could be adjusted to any value within that embedding scale region. This is particularly advantageous where it is known that the material will be subject to a particular form of distortion as a result of noise or processing which results in a non-zero mean.

Whilst in preferred embodiments the encoding scale comprises a predetermined number of adjacent regions of equal size are used, clearly it will be appreciated that the encoding scale may be configured in any suitable manner. For example, if it is known that certain values of the transform domain symbol I will never occur then the encoding scale could be arranged to exclude these. Also, it may be desirable where the characteristics of the transform domain symbols I are known to exhibit particular properties for regions to have unequal lengths so as to minimise the adjustment in this region.

DECODER

Figure 5 is a block diagram illustrating an apparatus for decoding embedded data in material information produced by the apparatus of Figure 2. The apparatus 200 receives embedded data material 125. A decoding processor 210 receives the embedded data material 125. The decoding processor 210 is provided with

information identifying which of the transform domain symbols have been embedded with data symbols. The decoding processor 210 identifies the transform domain symbols of the material information which represents an embedded symbol of the data. The decoding processor 210 compares the value of the selected transform domain symbol with an embedding scale and determines the value of the symbol of the data from the region of the scale in which the transform domain symbol falls. The data 135 is then output by the apparatus 200.

It will be appreciated that the decoding processor 210 may be arranged to decode more than one transform domain symbol of embedded data material 125. In situations where the embedded data material 125 comprises a number of frames, the decoding processor 210 may be arranged to decode transform domain symbols of the embedded data material 125 in different frames. Hence, some frames may have no transform domain symbols to decode whilst other frames may have more than one transform domain symbols to decode.

Typically, the data symbol is a binary '0' or a binary '1'. The data 135 may represent a Universal Material Identifier (UMID). The UMID provides for unique identification of the embedded data material 125.

Where the same data symbol has been embedded more than once to improve recoverability and robustness to processing and noise, the decoded values may be subject to a majority decision to determine a value for the data symbol.

In preferred embodiments when decoding data symbols a metric is generated indicative of the confidence in the decoding value. Decoded data symbols with a high confidence metric may be considered more reliable than those with a low confidence metric.

Figure 6 illustrates a technique for determining the confidence metric. A portion of the embedding scale illustrated in Figures 4A to 4C is shown, on which two data symbols I_1 and I_2 are indicated. The data symbol I_1 has a value of '3' and falls within the region encoding a binary '0'. The boundary B_1 between the pair of regions encoding a binary '0' and the pair of regions encoding a binary '1' is at the value '8'. The boundary B2 between the pair of regions encoding a binary '0' and the pair of regions encoding a binary '1' is at the value '-8'. The size of the region has the value S. A confidence metric C_1 representing a confidence that the value of the embedded

data symbol is a '0' is calculated according to the difference between the mid-point of the region in which the data symbol falls and the actual value of the data symbols. This is expressed by the equation given below:

$$C_m = S/2 - |m_n - I_m|$$

Where m_n is the value of the mid-point of the n-th region, C_m is the confidence of the data symbol I_m.

Therefore, for this example, a high confidence metric C is produced when the data symbol I is in the centre of the boundary region and a zero confidence metric is produced if the data symbol falls at the boundary. Therefore for the example data symbols I_1, I_2, shown in Figure 6, the confidence metric values C_1, C_2 are 1 and 3 respectively. As will be appreciated this is just one example of a technique for generating the confidence metrics and other techniques may be used.

The confidence metrics can be used to improve the likelihood of correctly recovering the embedded data, for both the majority decision decoding and error correction decoding where the data has been error correction encoded. For the example of majority decision decoding, the confidence metrics can be used to weight the value of each embedded symbol value. This would be particularly advantageous if the data symbols are embedded only twice. If the data symbol values are not the same at the decoder, then the value having the highest confidence can be determined as the decoded data value.

For the example embodiment in which the data has been error correction encoded, the confidence metrics can be used in the decoding algorithm for error correction decoding. For example, if the data has been encoded using a block code such as for example a Reed-Solomon code, then a symbol comprised of bits having a low confidence can be declared as an erasure and used in a decoder employing erasure decoding. For the example of convolutional coding, the confidence metrics can be used as soft decision values in a Viterbi decoder for the convolutional code.

UMIDs

A brief explanation will now be given of the structure of the UMID, with reference to Figure 7A and 7B. The UMID is described in SMPTE Journal March 2000. Referring to Figures 7A an extended UMID is shown to comprise a first set of

32 bytes of a basic UMID, shown in Figure 7B and a second set of 32 bytes referred to as signature metadata. Thus the first set of 32 bytes of the extended UMID is the basic UMID. The components are:

•A 12-byte Universal Label to identify this as a SMPTE UMID. It defines the type of material which the UMID identifies and also defines the methods by which the globally unique Material and locally unique Instance numbers are created.

•A 1-byte length value to define the length of the remaining part of the UMID.

•A 3-byte Instance number which is used to distinguish between different 'instances' of material with the same Material number.

•A 16-byte Material number which is used to identify each clip. Each Material number is the same for related instances of the same material.

The second set of 32 bytes of the signature metadata as a set of packed metadata items used to create an extended UMID. The extended UMID comprises the basic UMID followed immediately by signature metadata which comprises:

•An 8-byte time/date code identifying the time and date of the Content Unit creation.

•A 12-byte value which defines the spatial co-ordinates at the time of Content Unit creation.

•3 groups of 4-byte codes which register the country, organisation and user codes.

More explanation of the UMID structure is provided in co-pending UK patent application number 0008432.7.

In so far as the embodiments of the invention described above are implemented, at least in part, using software-controlled data processing apparatus, it will be appreciated that a computer program providing such software control and a storage medium by which such a computer program is stored are envisaged as aspects of the present invention.

Although particular embodiments have been described herein, it will be appreciated that the invention is not limited thereto and that many modifications and additions thereto may be made within the scope of the invention. For example, various combinations of the features of the following dependent claims could be made with the features of the independent claims without departing from the scope of the present invention.

CLAIMS

1. An apparatus for embedding data in material information, said apparatus comprising:

an embedding processor operable

to select at least one symbol of said material information for embedding a symbol of said data,

to compare a value of said material information symbol with an embedding scale divided into predetermined regions, each of said regions being associated with a value of said data symbol, and

consequent upon said comparison to arrange for said value of said material information symbol to fall within the nearest of said predetermined regions of said embedding scale associated with said value of said data symbol to be embedded, wherein at least one adjacent region of said embedding scale is associated with the same value of said data symbol to be embedded.

2. The apparatus of claim 1, wherein said predetermined regions of said embedding scale are paired, each pair being associated with the same value of said data symbol to be embedded, said pairs providing said at least one adjacent region having the same value of said data symbol to be embedded.

3. The apparatus of claim 1 or 2, wherein said predetermined regions of said embedding scale comprise a predetermined number of regions of equal size.

4. The apparatus of any preceding claim, wherein said value of said material information symbol is arranged to fall within the nearest of said predetermined regions by adjusting said material symbol to a predetermined value within the nearest of said predetermined regions of said embedding scale associated with said value of said data symbol to be embedded.

5. The apparatus according claim 4, wherein said predetermined value is a mid-value of the nearest of said predetermined regions of said embedding scale associated with said value of said data symbol to be embedded.

6. The apparatus of claim 4 or 5, wherein said predetermined regions have boundaries and said nearest of said predetermined regions of said embedding scale associated with said value of said data symbol to be embedded is determined by

calculating the difference between the value of said material information symbol and said boundaries of predetermined regions of said embedding scale associated with said value of said data symbol to be embedded and

consequent upon said difference selecting said nearest predetermined region of said embedding scale associated with said value of said symbol of said data to be embedded from the smallest difference between said material information symbol value and said boundaries.

7. The apparatus of any preceding claim, wherein said material information is one of audio material, video material and data material.

8. The apparatus of any preceding claim comprising a transform processor, wherein said material information is transformed by said transform processor into a transform domain, said data being embedded in said transform domain representation of said material information by said embedding processor by selecting at least one transform domain symbol and arranging the value of said transform domain symbol in accordance with the nearest of the predetermined regions of said encoding scale associated with the value of said transform domain symbol.

9. The apparatus of claim 8, wherein said transform processor is one of a Discrete Cosine Transform processor and a wavelet processor.

10. The apparatus of any preceding claim, wherein said material information comprises a plurality of frames, each frame comprising a predetermined plurality of material symbols.

11. The apparatus of claim 10, wherein said embedding processor selects at least one material information symbol for embedding said data symbol from at least one of said plurality of frames.

12. The apparatus of any preceding claim, wherein said data comprises a Universal Material Identifier (UMID).

13. The apparatus of any preceding claim, comprising an error correction encoder, said data being encoded by said error correction encoder in accordance with an error correction code prior to embedding data symbols of said data.

14. The apparatus of any of claims 1 to 12, wherein said encoding processor is operable to select a plurality of material information symbols, the value of the same data symbol being embedded onto said plurality of material information symbols.

15. The apparatus of any preceding claim, wherein said arranging for said value of said material information symbol to fall within the nearest of said predetermined regions of said embedding scale, comprises:

determining whether the value of said selected material information symbol falls within a region within said embedding scale which already represents the value of said data symbol to be embedded, and if so

not adjusting the value of said material information data symbol.

16. An apparatus for detecting and recovering data embedded in material information by the apparatus of any preceding claim, said apparatus for detecting and recovering embedded data in material information comprising:

a decoding processor operable

to identify at least one predetermined material information symbol bearing an embedded data symbol,

to compare the value of said material information symbol with said embedding scale divided into predetermined regions, each of said regions being associated with a value of said data symbol, and

to determine said value of said data symbol consequent upon said comparison with said regions.

17. The apparatus of claim 16, wherein said decoding processor is operable

to detect and recover data embedded by the apparatus of claim 14, and

to identify a predetermined number of material information symbols and determine said value of said data symbol data by a majority decision.

18. The apparatus of claim 16 or 17 when dependent on claim 11 wherein, said decoding processor is operable to identify at least one predetermined material information symbol bearing embedded data symbols from at least one of said plurality of frames.

19. The apparatus of any of claims 16 to 18 wherein, said predetermined regions of said embedding scale are paired, each pair being associated with the same value of said data symbol to be embedded, said pairs providing said alternative adjacent region having the same value of said data symbol to be embedded.

20. The apparatus of claim 19 wherein, said decoding processor is operable to compare said identified material information symbols with the boundaries of said region, and to generate a metric indicative of confidence of said decoded value of said data symbol consequent upon the distance of said material information symbol from said boundary of said region in which the material information symbol falls.

21. The apparatus of any of claims 16 to 20, operable to detect and recover data embedded by the apparatus of any of claims 8 to 13 comprising a transform processor operable to generate a transform domain representation of said material information, said decoding processor being operable

to identify at least one predetermined transform domain material information symbol bearing an embedded data symbol,

to compare the value of said transform domain material information symbol with said embedding scale divided into predetermined regions, each of said regions being associated with a value of said data symbol, and

to determine said value of said data symbol consequent upon said comparison with said regions.

22. The apparatus of any of claims 16 to 21 when dependent on claim 13, comprising an error correction decoder, said data being decoded by said error correction decoder in accordance with an error correction code.

23. A method of embedding data in material information, said method comprising the steps of:

a) selecting at least one symbol of said material information for embedding a symbol of said data;

b) comparing the value of said material information symbol with an embedding scale divided into predetermined regions, each of said regions being associated with a value of said data symbol;

c) determining the nearest of said predetermined regions of said embedding scale associated with said value of said data symbol to be embedded; and

d) consequent upon step (c) arranging for said material information symbol to fall within said nearest of said predetermined regions of said embedding scale associated with said value of said data symbol to be embedded, wherein at least one adjacent region of said embedding scale is associated with the same value of said symbol of said data to be embedded.

24. The method of claim 23, wherein step (d) comprises the steps of:

adjusting said material information symbol to a predetermined value within said nearest of said predetermined regions of said embedding scale associated with said value of said data symbol to be embedded.

25. The method of claim 24, wherein said predetermined location is a mid-point of said nearest of said predetermined regions of said embedding scale corresponding to said value of said symbol of said data to be embedded.

26. The method of any of claims 23 to 25, wherein said predetermined regions have boundaries and step (d) comprises the steps of:

determining said nearest of said predetermined regions of said embedding scale associated with said value of said data symbol to be embedded by

calculating the difference between the value of said material information symbol and said boundaries of said predetermined regions of said embedding scale associated with said value of said data symbol to be embedded; and

selecting a predetermined region of said embedding scale associated with said value of said data symbol to be embedded with the smallest difference between said value of said material information symbol and said boundaries.

27. The method of any of claims 23 to 26, comprising prior to step (a) the steps of:

transforming said material information into a transform domain, said steps (a), (b), (c) and (d) being performed on transform domain material information.

28. The method of any of claims 23 to 27, wherein said material information comprises a plurality of frames, each frame comprising a plurality of material symbols and step (b) comprises the steps of:

selecting at least one material symbol for embedding said data symbol from at least one of said plurality of frames.

29. The method of any of claims 23 to 28, comprising prior to step (a) the step of:

encoding said data in accordance with an error correction code.

30. The method of any of claims 23 to 28, wherein step (a) comprises the step of:

selecting a plurality of material information symbols, and

the value of the same data symbol is embedded onto said plurality of material information symbols in accordance with steps (b) to (d).

31. The method of any of claims 23 to 30, wherein step (d) said arranging for said material information symbol to fall within said nearest of said predetermined regions, comprises:

determining whether the value of said selected material information symbol falls within a region within said embedding scale which already represents the value of said data symbol to be embedded, and if so

not adjusting the value of said material information data symbol.

32. A method of detecting and recovering embedded data in material information as embedded by said method for embedding data in material information of any of claims 23 to 31, said method of detecting and recovering embedded data in material information comprising the steps of:

identifying at least one material information symbol bearing an embedded data symbol,

comparing the value of said material information symbol with said embedding scale divided into predetermined regions, each of said regions being associated with a value of said data symbol, and

determining a value of said data symbol consequent upon the comparison of said material information symbol value with said embedding scale.

33. The method of claim 32 for detecting and recovering data embedded in accordance with the method of claim 30, wherein a predetermined number of material information symbols are identified, the method comprising the step of:

determining a value of said data symbol data by a majority decision on said predetermined number of material information symbols.

34. The method of claim 32 or 33, when dependent on claim 28 wherein identifying said material information symbol comprises the step of identifying at least one material information symbol bearing an embedded data symbol from at least one of said plurality of frames.

35. The method of any of claims 32 to 33 when dependent on claim 29, comprising the step of:

decoding said data in accordance with an error correction code.

36. A computer program which when loaded on to a data processor performs the steps of any one of claims 23 to 35.

37. A computer program providing computer executable instructions, which when loaded onto a computer configures the computer to operate as the apparatus claimed in claims 1 to 22.

38. A computer program product having a computer recordable medium which has recorded thereon information signals representative of the computer program of claims 36 and 37.

39. A signal representing material information in which data is embedded by the apparatus according to any one of claims 1 to 15.

40. An apparatus for embedding data in material information as hereinbefore described with reference to Figure 2.

41. An apparatus for detecting and recovering embedded data in material information as hereinbefore described with reference to Figure 5.

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Application No:	GB 0102119.5	**Examiner:**	Ms Ceri Witchard
Claims searched:	1-41	**Date of search:**	11 July 2001

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): H4F (FBB)

Int Cl (Ed.7):

Other: Online: WPI, EPODOC, JAPIO, INSPEC

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	EP 1001604 A2	CANON KK See page 6 line 40 to page 7 line 25.	-
X	WO 00/65536 A1	MASSACHUSETTS INSTITUTE OF TECHNOLOGY See especially page 49 line 13 to page 53 line 31.	1-3, 5, 7-12 and 23, 25, 28, 36-39 at least

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